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Establishing Crop Acreage Flexibility Restraints for Subregions of the Texas High Plains

G.D. Condra
R.D. Lacewell

Texas Water Resources Institute

Texas A&M University

ESTABLISHING CROP ACREAGE FLEXIBILITY RESTRAINTS

FOR SUBREGIONS OF THE TEXAS HIGH PLAINS

Gary D. Condra
Ronald D. Lacewell

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ABSTRACT

Cropping pattern shifts in many aggregate linear programming (LP) models need to be constrained due to institutional, marketing machinery, and price uncertainty factors. The purpose of this study was to estimate constraints which are referred to as flexibility restraints for major crop acreages in subregions of the Texas High Plains for use in a LP model that was developed to derive water and other input demand.

Alternative estimating models for establishing acreage flexibility restraints were developed using methodology and model formulation presented in the literature. The results of these models in estimating flexibility restraints were evaluated using statistical measures and subjective analysis.

Models which were analyzed ranged from a simple linear regression model in which the current year's acreage is expressed as a function of last year's acreage to a multiple regression model in which economic and climatological variables were considered. The multiple regression model as formulated and estimated did not provide satisfactory results. However, as in many of the earlier studies the simpler models did provide acceptable performance. From among the simplier models one was selected based on statistical measures and a prioria expectations. The model was used to calculate crop acreage flexibility restraints for three subregions of the Texas High Plains.

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ESTABLISHING CROP ACREAGE FLEXIBILITY RESTRAINTS FOR SUBREGIONS OF THE TEXAS HIGH PLAINS

Introduction

A linear programming (LP) model of the Texas High Plains was developed to estimate derived demand schedules for various agricultural production inputs; such as water, energy, fertilizer, and herbicides (Condra, et.al.). Models of this type may be designed to minimize costs of producing a given level of output of various crops (Shumway) or to maximize net income to a given bundle of resources (Gray and Trock). Cost minimizing models have a relatively more fixed cropping pattern since some prespecified quantity of each product is forced into solution. This means only methods of production are allowed to vary. Thus, several dryland acres of a particular crop may replace one irrigated acre of that crop, but that particular crop is restrained from leaving the solution, even if it is less profitable than other crops included in the model.

Alternatively, profit maximizing models suffer a more serious shortcoming in that crops which are less profitable per unit of fixed resource can be completely eliminated from solution depending upon how input resources are incorporated into the model. This means that in profit maximizing models, massive shifts in regional cropping patterns to the most profitable crop can occur. Shifts of this magnitude are highly unrealistic in terms of actual producer behavior and stem primarily from the normative characteristics of LP. Due to institutional, marketing, machinery and price factors, adjustments in cropping patterns follow a more gradual process. If such a shortcoming is allowed to exist in an LP model of this type, then the demand schedules which are generated are normative schedules and may bear little resemblance to the actual derived demand which exists for a given input.

The Texas High Plains LP model was developed as a profit maximizing model because objectives of the study included an examination of the relationships between levels of crop prices and derived input demand. Therefore, one of the major problems which had to be overcome was that of constraining cropping pattern shifts to some realistic levels while allowing the profit maximizing assumption to operate. An identical problem exists in the use of LP or recursive programming (RP) in supply response studies (Day; Henderson; Schaller). In fact, supply response and derived input demand studies differ only in the questions asked since supply response and derived demand are the output and input aspects of the same production process.

Day (pp. 110-111) first proposed a solution to the problem of constraining cropping pattern shifts by limiting adjustments in acreage of a given crop to some percentage of the previous year's acreage. This "flexibility constraint", as Day refers to the limitation of cropping pattern shifts, bears a close conceptual resemblance to its forerunner, Nerlove's coefficient of adjustment. Essentially this flexibility constraint or restraint is composed of a base acreage (usually the previous year's acreage) and a flexibility coefficient (B). Thus:

$$X_t = (1 \pm B)\ (X_{t-1})$$

where

X_t = acreage of a given crop in year t

B = the flexibility coefficient

X_{t-1} = acreage of a given crop lagged one period

There are various reasons why producers would not be expected to make massive shifts in cropping patterns to the 'optimum' solution in a given year: (1) diversification to minimize market, weather, and insect risk (2) personal preference and expertise (3) fixed investments in specialized equipment and (4) differences in perceptions of expected prices for crops and inputs. The use of Day's flexibility restraint allows relaxation of the assumption that the producer will allocate resources to maximize net returns by constraining the LP solution to a reasonable subset of possible solutions. The more reasonable assumption which underlies the constrained model is that producers' response will tend toward the 'optimum' over time (Miller).

Previous Studies

The use of flexibility restraints is the most prevalent approach to constraining normative LP models for predictive uses. While most of the studies using this approach have a common conceptual framework, there are many alternative methods for the estimation of the flexibility coefficient (B). These techniques range from simple mathematical averages of year to year fluctuations to general linear regression models including variables such as rainfall, crop prices, etc. (Sahi and Craddock; Miller).

Flexibility restraints were estimated for twelve crops in 160 regions by Henderson in a study reported in 1959. He used a simple linear regression model to estimate the flexibility coefficient by expressing each year's acreage as a function of the previous year's acreage and segregating data into periods of increase and decrease. These restraints were incorporated into a recursive programming model designed to predict and explain allocation of land among various crops.

Day reported the use of flexibility restraints in a production response study of cotton and alternative field crops in the Mississippi Delta. The approach used in this study was basically an extension of the Henderson model with consideration given to time paths of expansion.

Schaller reported the use of several alternative techniques for estimation of flexibility restraints used in the U.S. Department of Agriculture national model of aggregate production response. These approaches fall into four categories: (1) 'B' estimated as the mean of absolute percentage deviations in acreage (2) '$\overline{B}$' as the mean of increasing percentage deviations and '$\underline{B}$' as the mean of decreasing percentage deviations (3) '$\overline{B}$' as the maximum percentage increase and '$\underline{B}$' as the maximum percentage decrease in acreage and (4) 'B' estimated by simple linear regression as reported by Day and Henderson.

Miller used statistical measures to evaluate alternative procedures for estimation of flexibility restraints. His analysis revealed three critical factors in selecting a procedure. First, there is the reliability of the LP model is selection of the appropriate bound. As model reliability increases, bounds may be less restrictive without increasing total error. Secondly, selection of the base is of great importance, since different variances are associated with alternative bases. Miller concludes that the mean of the variable should be preferred to the previous year's acreage as a base, but this conclusion rests on the assumption that the acreages are independently distributed with no trend. The third factor which he points out is the absolute magnitude of the restraints. This factor also relates to the reliability of the model in determining direction of change.

Sahi and Craddock compared results of a recursive linear programming (RP) model applied in Canada using flexibility restraints estimated by three alternative procedures: (1) the third technique mentioned in Schaller's study, where $\overline{B}$ and $\underline{B}$ are defined as the maximum proportionate increases and decreases in a historical series (2) the technique used by Day and Henderson where B is estimated using simple linear regression and (3) estimation of $(1 \pm B)$ directly using a multiple linear regression model which included variables for crop prices, rainfall, etc. This study concluded that the simple linear regression model gave superior results over the use of maximum proportionate deviations. It was likewise concluded that results of the multiple linear regression model were superior to both the other models. The latter approach, unlike its' predecessors, provided for changes in the magnitude of the flexibility coefficient in response to changes in climatological and economic factors.

Objectives

The general objective of this study was to develop flexibility restraints for acreages of major crops in the Texas High Plains in order to effectively constrain the LP derived input demand model previously mentioned. More specifically, the objectives were:

1. To estimate flexibility coefficients for major crops of the Texas High Plains, by subregions, using alternative statistical techniques.
2. To evaluate alternative techniques for estimation of flexibility coefficients in terms of expected error (compared to historical data) associated with the use of each in a general LP model of the Texas High Plains.

3. To select a single procedure or model for estimation of flexibility coefficients and apply the model to establish flexibility restraints for all crops and all subregions included in the Texas High Plains LP model.

Procedures

The study areas were chosen to coincide with those used in studies by Condra, et.al. (p. 3) and Adams (p. 4). These areas correspond to Subregions II, III, and IV of the Texas High Plains as defined in the Texas Crop Budgets (Economists-Management) and will herinafter be referred to as HPII, HPIII, and HPIV.

The major crops which were considered were cotton, sorghum, and wheat in all three areas; soybeans in HPII and III; and corn in HPII. These crops also correspond to those considered in previously cited studies (Condra, et.al. p. 12; Adams, p. 43).

Historical time series data for crop acreages and prices were taken from sources published by the Texas Crop and Livestock Reporting Service. Cotton and wheat acreage data were used for the period, 1953-1973. However, sorghum and corn acreage data were not available prior to 1959 and 1968, respectively. The historical data series for soybeans was not continuous and included the periods 1956-1959 and 1968-1973. Also, at the time this study was done, published county data were not available for the 1974 crop year. Therefore estimates were made based on published estimates by crop reporting district of 1974 acreages (Texas Crop and LIvestock Reporting Service). Rainfall data were taken from regional series published by the U.S. Department of Commerce.

Alternative Models

The simpler models set forth in Schaller's study were not considered. The models based on the mean of percentage deviations were conceptually identical to the simple linear regression model and thus were discarded. Sahi and Craddock found that the model based on maximum proportionate increases (and decreases) produced results which were significantly inferior to both the simple and multiple linear regression models. Therefore, all the models which were evaluated were variations of the simple and multiple linear regression models discussed by Sahi and Craddock.

Model 1

This model is basically identical to Sahi and Craddock's simple linear regression model. This year's acreage is expressed as a function of last year's acreage. An important difference in estimating procedure is that rather than separating the data into two sets (years of acreage increase and years of acreage decrease) and estimating two equations, a dummy variable was used and a single equation was estimated. The effect of the dummy variable for distinguishing between years of increase and years of decrease in one equation was to double the degrees of freedom, thus increasing efficiency and power of the statistical tests. Basically the model is as follows:

$$AC = b_1 ACLAG + b_2 ACDOWN + e$$

where:

AC = Acreage of a given crop in the current year

ACLAG = Acreage of a given crop in the previous year

ACDOWN = A dummy variable which distinguishes years of increase from years of decrease.[1]
If AC > ACLAG then ACDOWN = 0
If AC < ACLAG then ACDOWN = ACLAG

Thus:

$$1 + \overline{B} = b_1 \text{ and } 1 - \underline{B} = b_1 + b_2$$

Model 2

This model differs from Model 1 only by addition of a variable for the simple linear trend estimate of acreage. The estimated or current acreage which results from model application is partially a weighted average of the previous year's acreage and the trend estimate. This approach tends to offset the effects of extremely high or low acreages in a given year, but it also forces flexibility restraints to fall between the trend estimate and the previous year's acreage in most cases. This model is also sensitive to the assumption that the past trend in acreage will continue in the same direction, an assumption which is not easily defended under conditions of changing input and crop prices.

Mathematically:

$$AC = b_1 ACLAG + b_2 TRENDAC + b_3 ACDOWN + e$$

where

AC = Acreage of a given crop in the current year.

ACLAG = Acreage of a given crop in the previous year.

TRENDAC = Estimate of the acreage of a given crop in the current year from a simple linear trend model.

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[1]Perhaps the dummy variable should be more appropriately termed a quasi-dummy variable. Explanation of the model formulation using the definitions in the text is as follows:
Since $1 + \overline{B} = b_1$ and $1 - \underline{B} = b_1 + b_2$ then $b_2 = -\overline{B} - \underline{B}$ so $AC = (1 + \overline{B})ACLAG + (-\overline{B} - \underline{B})ACDOWN$. If $AC > ACLAG$ then $ACDOWN = 0$ and drops out of the equation such that $AC = (1 + \overline{B})ACLAG$. If $AC < ACLAG$ then $ACDOWN = ACLAG$, hence $AC = (1 + \overline{B})ACLAG + (-\overline{B} + \underline{B})ACLAG$ or $AC = (1 + \overline{B} - \overline{B} - \underline{B})ACLAG$ and $AC = (1 - \underline{B})ACLAG$. This is basically the same models as in the literature but estimated in a single equation.

ACDOWN = A dummy variable which distinguishes years of increase from years of decrease.
If $AC > ACLAG$ then $ACDOWN = 0$
If $AC < ACLAG$ then $ACDOWN = ACLAG$

Thus:

$1 + \bar{B}$ and $1 - \underline{B}$ are not calculated directly and flexibility restraints are calculated by substitution of values for ACLAG, TRENDAC, and ACDOWN in the model.

<u>Model 3</u>

Model 3 is a compromise between Model 1 and Model 2. While a trend variable is not included, the base acreage is changed from the previous year's acreage to a moving average of the past three year's acreage. This modification removes some effects of extremely high and low acreages in the previous year while allowing trends in acreage to change direction. Mathematically:

$$AC = b_1 AVLAG + B_2 AVDOWN + e$$

Where:

AC = Acreage of a given crop in the current year
AVLAG = Previous three years' moving average acreage of a given crop
AVDOWN = A dummy variable which distinguishes between above and below average acreage years.
If $AC > AVLAG$ then $AVDOWN = 0$
If $AC < AVLAG$ then $AVDOWN = AVLAG$

Thus:

$$1 + \bar{B} = b_1 \text{ and } 1 - \underline{B} = b_1 + b_2$$

<u>Model 4</u>

The last model formulated is a general linear regression model of the type employed by Sahi and Craddock. It was postulated in an attempt to relate flexibility restraints to economic and climatological variables in addition to the previous year's acreage or average acreage. Unlike the previous models, (1 + B) is estimated directly as the dependent variable. Variables are included for the price of the crop, prices of substitute crops, government program effects, and pre-planting rainfall. The previous year's acreage was also included to test the hypothesis that the flexibility coefficients should vary inversely with the size of the previous year's acreage (Sahi and Craddock).

Mathematically:

$$\frac{X_t}{X_{t-1}} = a + b_1 X_{t-1} + b_2 P_{t-1} + b_3 S_{t-1} + b_4 G_t + b_5 R_t + b_6 D + e$$

Where:

X_t = Acreage of a given crop in year t

X_{t-1} = Acreage of a given crop lagged one period

P_{t-1} = Price of the crop lagged one period as a proxy for expected price

S_{t-1} = Prices of substitute crops lagged one period as proxies for expected prices

G_t = Dummy variable for government acreage control programs; if government programs were in force then G = 1, otherwise G = 0

R_t = Pre-planting rainfall in inches

D_t = Dummy variable to segregate years of increases and decrease; IF $X_t < X_{t-1}$ then D = 1, otherwise D = 0

Estimation of the Models

All models formulated were fitted using the Statistical Analysis System (Barr and Goodnight). Models 1 and 2 were estimated for all crops except corn. There were insufficient data to estimate Model 2 for corn and likewise to estimate Model 3 for corn and soybeans. Model 3 was estimated for cotton, sorghum, and wheat.

Model 4 was estimated for cotton only. At the time Model 4 was being fitted, insufficient data were available to estimate the model using regional totals. Therefore time series and cross-sectional analysis were combined using county totals. This model proved highly unsatisfactory and was abandoned for all other crops. However, one of the better variations of Model 4 is presented in the results section of this study with some hypotheses concerning the lack of success.

Long Run Flexibility Restraints

The flexibility restraints which were estimated using Models 1-4 are short run in nature because they deal with one year's fluctuation. In a recursive programming model they become long run in nature because successive generation of solutions results in a compounding effect of increases or decreases in acreage. This effect led to the development of the concept of time paths of expansion (Day). This approach was modified slightly for use in the Texas High Plains LP model to develop 'long run' flexibility restraints. The long run was specified arbitrarily as three years, however it should not be assumed that this period represents full adjustment. Certainly, the long run may be much longer for some producers depending on the type of equipment required, level of care and maintenance of equipment, age of operators, employment alternatives of operators, etc. On the other hand the long run probably is at least three years if it is considered as that time which must elapse before producers begin to make decisions based on total rather than variable costs of production.

Long run flexibility coefficients were developed as $(1 \pm B)^t$ where 'B' is the coefficient derived from Models 1-4 and t = 3 years. This simply means that if the acreage of a given crop can increase to (1.05) X Base in one year, it can increase to $(1.05)^3$ X Base in three years. It should be noted that this procedure is conceptually sound for Model 1 restraints, not directly applicable to Models 2 and 4, and somewhat less obvious for Model 3. Since Model 3 uses a moving average for the base acreage, theoretically the average should be recomputed using each successive estimate to adjust the base. This was not done for the sake of simplicity, but it was not felt that the distortion over a three year period would be significant.

Results and Analysis

Alternative models for estimation of crop acreage flexibility coefficients are presented for each of the three subregions in Tables 1-3. Estimates of the regression coefficients, R^2, and standard deviation are shown with levels of statistical significance for each beta coefficient presented below the coefficient. F-values are not presented because all were statistically significant at the .0001 level. It should be noted that the normal interpretation of R^2 values does not apply since Models 1-3 were estimated with the intercept constrained to zero. All variables shown in these tables have been defined in the section on procedures.

HPII

Alternative estimating equations for all five crops in HPII are shown in Table 1. As stated earlier, only Model 1 was estimated for corn and only Models 1 and 2 were estimated for soybeans. The signs on all beta coefficients are consistent with theory and R^2 values are relatively high as expected when estimated with a constrained intercept.

Model 1 seems to be somewhat superior to the other models in estimation of corn, wheat, and soybean acreages. It is the only model presented for corn and thus wins by default. In the case of wheat it has a slightly

Table 1. Alternative Estimating Equations for Flexibility Coefficients, Subregion II, Texas High Plains, 1975

Crop	Model No.	ACLAG	AVLAG	TRENDAC	ACDOWN	AVDOWN	R^2	Std. Dev.
Corn:	1	1.9147 (.0005)			-1.0921 (.0064)		.9906	21.11
Cotton:	1	1.0525 (.0001)			- .1718 (.0032)		.9878	65.32
	2	.6404 (.0005)		.4053 (.0116)	- .1370 (.0070)		.9917	55.42
	3		1.0872 (.0001)			-.2223 (.0005)	.9894	60.79
Sorghum:	1	1.2132 (.0001)			- .3464 (.0006)		.9859	165.49
	2	.3521 (.3817)		.7673 (.0457)	- .1936 (.0645)		.9904	142.98
	3		1.1279 (.0001)			-.2456 (.0009)	.9933	114.02
Wheat:	1	1.1096 (.0001)			-.2349 (.0001)		.9915	126.06
	2	.8795 (.0001)		.2204 (.1808)	-.2097 .0002		.9923	123.06
	3		1.1486 (.0001)			-.3016 (.0001)	.9860	158.11
Soybeans:	1	1.6233 (.0019)			-.9093 (.0298)		.9379	24.65
	2	1.2590 (.0610)		.2137 (.4230)	-.6964 (.1489)		.9461	25.15

lower R^2 and slightly higher standard deviation than Model 2, however the beta coefficient for TRENDAC in Model 2 is not significant at even the .10 level. This same situation exists in the case of Model 1 for soybeans.

Model 2 is favored over the other models only in the case of cotton where it has a higher R^2 and lower standard deviation than the other models and all beta coefficients are significant at the .05 level.

Model 3 has a higher R^2 and lower standard deviation in the equation for sorghum than other models and all coefficients are highly significant.

One variation of Model 4 for cotton is presented below:

$$\frac{X_t}{X_{t-1}} = \underset{}{1.5283} + \underset{(.0001)}{.0134P} - \underset{(.0329)}{.0392T} + \underset{(.0001)}{.1149D}$$

$$R^2 = .5977 \quad \text{Standard Deviation} = .1373 \quad F = \underset{(.0001)}{30.71}$$

Where

X = acreage of upland cotton

P = price per pound of upland cotton in cents in year t-1

T = year; 1950 = 1

D = dummy; If $X_t < X_{t-1}$ then D = 1, otherwise D = 0

Variables appearing in the original formulation of Model 4 which are not included in this variation were dropped for lack of significance. This model is statistically sound; however, when values of 40¢ per pound for cotton and the T of 1974 are substituted, it is found that the resulting flexibility coefficients are 1.1235 and 1.0086. The latter value precludes any decrease in acreage for 1974 over 1973. This occurrence is most easily explained by examining the historical price structure for cotton. Since the removal of federal acreage control programs, prices have risen significantly above the average levels of periods under these programs. Therefore, when this structure is extrapolated to 1974, the results are not realistic. A different situation seems to have affected the significance levels of other variables. Prices of substitute crops and cotton were highly correlated positively and cotton price and the dummy variable for government programs were negatively correlated. The resulting multicollinearity yielded nonsignificant beta coefficients for these variables.

HPIII

Model 1 for cotton, wheat, and soybeans shown in Table 2 is somewhat better than the other two models. In the case of wheat it has a slight advantage over Model 2 in all respects. However, in the case of cotton and soybeans, it is selected over Model 2 because of statistically insignificant beta coefficients in the latter model.

Model 2 was not selected as the preferred model for any crop in HPIII.

Model 3 was selected as the best sorghum model with the highest R^2 and lowest standard deviation of the three models.

Model 4 for cotton in HPIII was somewhat more satisfactory than was the case in HPII. Variables for rainfall and substitute crop prices did produce significant beta coefficients, but again the estimates of flexibility coefficients were not satisfactory. The model was estimated as:

$$\frac{X_t}{X_{t-1}} = 1.8179 + \underset{(.0001)}{.0154P} - \underset{(.0018)}{.1289S} - \underset{(.0001)}{.0483T} + \underset{(.0001)}{.0364R} + \underset{(.0001)}{.0549D}$$

$$R^2 = .8187 \qquad \text{Standard Deviation} = .0512 \qquad \underset{(.0001)}{F = 43.34}$$

Where:

X = acreage of upland cotton

P = price of upland cotton in cents per pound

Table 2. Alternative Estimating Equations for Flexibility Coefficients, Subregion III, Texas High Plains, 1975

Crop	Model No.	ACLAG	AVLAG	TRENDAC	ACDOWN	AVDOWN	R^2	Std. Dev.
Cotton:	1	1.0619 (.0001)			-.1253 (.0028)		.9942	97.74
	2	.8795 (.0001)		.1820 (.2116)	-.1205 (.0036)		.9947	95.94
	3		1.1015 (.0001)			-.1954 (.0025)	.9883	138.61
Sorghum:	1	1.1222 (.0001)			-.2407 (.0028)		.9903	108.57
	2	.9281 (.0348)		.1767 (.6213)	-.2067 (.0452)		.9906	112.09
	3		1.1497 (.0001)			-.2724 (.0014)	.9930	90.49
Wheat:	1	1.3924 (.0001)			-.5826 (.0001)		.9718	11.69
	2	1.3204 (0001)		.0653 (.5986)	-.5740 (.0001)		.9722	11.92
	3		1.6655 (.0001)			-.9934 (.0001)	.9444	16.95
Soybeans:	1	1.5614 (.0006)			-1.0856 (.0076)		.9012	7.57
	2	1.2814 (.0079)		.3524 (.2213)	-1.0206 (.0111)		.9289	7.04

S = price of grain sorghum in \$/cwt

T = year; 1950 = 1

R = rainfall in inches (March, April, and May)

D = dummy; If $X_t < X_{t-1}$ then D = 1, otherwise D = 0

This model appears very good conceptually but estimates of the flexibility coefficients for 1974 are .9221 and .8672. Unlike HPII, HPIII cotton acreage could not possibly increase using this model.

HPIV

Alternative estimating equations for Models 1-3 are presented in Table 3. Model 1 was selected over Model 2 for cotton because of a non-significant coefficient for TRENDAC in Model 2. Model 3 was clearly superior for sorghum and Model 2 was somewhat better for wheat despite the .0584 level of significance for the beta coefficient of TRENDAC. Model 4 for cotton in HPIV is not presented because none of the variables in the original formulation were significant.

Selection of Standard Models

The previous analysis of the results revealed that Model 4 was not satisfactory (as estimated) and Model 2 was not significantly better than Models 1 and 3. Model 2 was dropped from the selection process because it was considerably more difficult to use and, as stated, produced only marginally superior results. Model 2 was determined earlier to be superior for cotton in HPII and wheat in HPIV. The next best model in each case was Model 3. This rearrangement left Model 1 superior in the following situations:

Table 3. Alternative Estimating Equations for Flexibility Coefficients, Subregion IV, Texas High Plains, 1975

Crop	Model No.	ACLAG	AVLAG	TRENDAC	ACDOWN	AVDOWN	R^2	Std. Dev.
Cotton:	1	1.1619 (.0001)			-.2512 (.0009)		.9856	38.04
	2	.9829 (.0001)		.1737 (.2040)	-.2466 (.0010)		.9870	37.28
	3		1.2213 (.0001)			-.3496 (.0013)	.9798	46.16
Sorghum:	1	1.1490 (.0001)			-.2748 (.0011)		.9886	49.09
	2	1.1009 (.0370)		.0431 (.9187)	-.2657 (.0337)		.9887	51.25
	3		1.1335 (.0001)			-.2589 (.0030)	.9900	45.36
Wheat:	1	1.3537 (.0001)			-.6095 (.0006)		.9418	6.95
	2	1.0786 (.0001)		.2760 (.0584)	-.6184 (.0003)		.9526	6.44
	3		1.5951 (.0001)			-.9386 (.0002)	.9476	6.78

HPII - corn, wheat, soybeans

HPIII - cotton, wheat, soybeans

HPIV - cotton

Model 3 was preferable in the remaining situations:

HPII - cotton, sorghum

HPIII - sorghum

HPIV - sorghum, wheat

There was no question in the case of corn and soybeans since Model 1 was the only remaining model for estimation of flexibility restraints. Model 2 was superior in two out of three regions for cotton and wheat while Model 3 was superior in all regions for sorghum.

Model 3 was chosen as the standard model for all crops (except corn and soybeans) in all regions for two basic reasons. First, cotton acreages in 1974 were atypical because of weather conditions providing a poor base for estimation of flexibility restraints with Model 1. This made it seem advisable to use Model 3 for both sorghum and cotton. Secondly it was deemed desirable to maintain consistent calculation procedures when possible. It would have been possible to use Model 1 for estimation of flexibility restraints for wheat but acreage of wheat in 1974 and 1975 was also thought to be atypical because of market conditions.

Both short run and long run flexibility restraints were estimated using techniques described in the sections on procedures. Model 1 was used for corn and soybeans and Model 3 was used for cotton, sorghum, and wheat. These estimates are shown in Table 4. These flexibility restraints were in turn employed in development and application of a Texas High Plains LP model with results reported by Condra, et.al. and Adams.

Table 4. Flexibility Restraints for Crop Acreages, Texas High Plains, 1975

Item	Acres[a] 1974	Acres[a] 1972-'74 Average	$1+\bar{B}$	$1-\underline{B}$	Flexibility Restraints: Short Run[b] Upper	Short Run[b] Lower	Long Run[c] Upper	Long Run[c] Lower
	---1,000,000----				--------1,000,000 Acres----------			
HPII:								
Corn	.381	.262	1.915	.823	.730	.314	2.676	.212
Cotton	.714	.629	1.087	.865	.684	.544	.808	.407
Sorghum	1.155	1.166	1.128	.882	1.315	1.028	1.674	.800
Wheat	1.505	1.331	1.149	.847	1.528	1.127	2.019	.809
Soybeans	.074	.079	1.623	.714	.120	.053	.316	.027
HPIII:								
Cotton	1.206	1.307	1.102	.910	1.140	1.189	1.749	.985
Sorghum	.656	.768	1.150	.877	.883	.674	1.168	.518
Wheat	.226	.175	1.666	.672	.292	.118	.809	.053
Soybeans	.011	.013	1.561	.476	.017	.005	.042	.001
HPIV:								
Cotton	.462	.490	1.221	.872	.598	.427	.892	.325
Sorghum	.327	.376	1.134	.875	.426	.329	.548	.252
Wheat	.092	.073	1.595	.657	.116	.048	.296	.021

[a] 1974 acreages estimated prior to published statistics.

[b] Short Run Flexibility Restraints = $(1+\bar{B})$ X (1972-'74 average) except corn and soybeans, where Base = 1974 acreage

[c] Long Run Flexibility Restraints = $(1+\bar{B})^3$ X (1972-'74 average) except corn and soybeans, where Base = 1974 acreage.

Evaluation

One of the objectives of this study was to evaluate the alternative models in terms of expected error associated with the use of each in estimation of flexibility restraints as employed in the LP model. However, during the development stages of a derived input demand model (LP) for water there exists little basis for testing the reliability of the model. This is somewhat more easily done with other inputs which have fluctuating prices within the range of historical data. Unfortunately for both the developers of the model and the producers of the Texas High Plains, the prices of energy, fertilizer, and herbicides are far above the historical range in most cases. Thus validation of the model must rest on future performance.

In the absence of reliability estimates for the LP model, evaluation of the alternative techniques must rely on comparison of the standard error as employed in the analysis of results. Weighted average coefficients of variation are shown in Table 5. Regional coefficients range from 11.70 to 15.61 percent and coefficients by crop range from 9.40 percent for sorghum to 33.53 percent for soybeans. It should be noted that soybeans are not predominant in any region and the remaining coefficients are less than 16 percent.

The measures of error which have been discussed are not adequate to accurately specify the expected error from application of the model, thus it must be concluded that this objective was not totally accomplished.

Table 5. Coefficients of Variation for Flexibility Restraints, Texas High Plains, 1975

Crop	Subregion			Average[a]
	HPII	HPIII	HPIV	
	--------- % --------			
Corn	13.55	---	---	13.55
Cotton	11.02	11.61	15.72	12.23
Sorghum	9.02	9.27	11.05	9.40
Wheat	12.61	30.47	31.26	15.77
Soybeans	31.81	45.26	---	33.53
Average[a]	11.70	13.09	15.61	12.63

[a] weighted by 1974 estimated acreage shown in Table 4.

Conclusions and Limitations

Four major conclusions were drawn from this study concerning the alternative models which were evaluated: (1) Models 1-3 generated essentially comparable results in terms of R^2 and standard deviations (2) Model 1 was relatively more volatile than Models 2-3 because in some cases the previous year's base acreages were produced under atypical conditions (3) Model 2 was relatively less flexible than Models 1 and 3 due to reduced sensitivity to changes in direction of trend in a particular crop's acreage (4) Model 4 as formulated and estimated provided generally unsatisfactory results.

Model 3 was selected where possible for the estimation of flexibility restraints because it provided a compromise between Models 1 and 2 in terms of flexibility and volatility. It was concluded that the flexibility restraints which were derived using this model are superior to abitrary restraints which have been used in some models, however, a combination of subjective judgement and statistical flexibility coefficients may provide more satisfactory results than either alone. While standard deviations for wheat in HPIII-IV and soybeans in HPII-III appear relatively high, the weighted coefficients of variation for each subregion and overall range from 11.70 to 15.61 percent.

Although the flexibility restraints generated using Model 3 were generally concluded to be satisfactory, they are still subject to a number of serious limitations. First, historical time series data used in estimation of these models were taken from a period in which there was a predominant influence of federal crop acreage control programs. Therefore what changes have occurred and are still occurring in producer behavior patterns under the increasing influence of relatively more free market conditions is not known at this time. Secondly, the flexibility restraints which were estimated are not sensitive in magnitude to changes in economic and climatalogical variables such as prices and rainfall. Thirdly, no formal evaluation has been made of the joint error associated with the use of these flexibility restraints in the Texas High Plains LP model. This evaluation must be made before it is possible to accurately assess the effectiveness of these restraints.

Need For Further Study

Several areas were discovered in the course of this study which seemed to warrant further investigation. Ryan and Abel used a price series adjusted for the influence of government programs which might provide improvements in the performance of Model 4. It is also possible that reformulation of Model 4 to some form of first differences might overcome some of the problems associated with multicollinearity.

Walker and Penn developed a multiple equation model for analysis of crop acreage response in which they used Joint Generalized Least Squares (Zellner) for estimation of the equations. This technique was used because it was felt that there was possible correlation of disturbance terms across equations. It is quite likely that this same situation exists in the use of Models 1-4 for the estimation of flexibility restraints and it seems advisable that this technique be investigated as a means of improving estimates.

The use of 'random regression coefficients' (Langham) is another technique which may relate to the estimation of flexibility restraints. Since the flexibility coefficients in Models 1-3 are in fact a function of the regression coefficients, this approach should be investigated.

The additional techniques which have been discussed above as needs for further study should in no way detract from the usefulness or validity of the flexibility restraints derived in this study. Instead, they are provided as possible avenues in which other studies may build on the foundation provided in this study. The area of flexibility restraint estimation is one in which a great need has been realized and not nearly enough work has been done.

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